Space Weather Technical Forecast

Issued on Wednesday, 04 January 2023 at 12:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Moderate solar activity throughout. Active electron fluence 04 January expected to decline, perhaps returning later in period. Chance of G1/Minor Geomagnetic Storm intervals on 04/05 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with occasional C-class flares. However, much of the flare activity can be attributed to an active region beyond the eastern limb in the southern hemisphere. There are currently five sunspot regions on the visible disc. Most regions are either steady state, or in slow decline apart from AR3181 (Cso/Beta) in the southeast, which has developed some small peripheral spots. AR3180 (Dsi/Beta) in the northeast remains the largest region, but the trailer portion has shown some slight decay in recent imagery. A region beyond the southeast limb produced a long-period C4.0 flare starting around 03/0620 UTC. This produced a large, fast CME (coronal mass ejection) which has been modelled, but does not have an Earth-directed component. No Earth-directed CMEs have been observed in available imagery. However, a filament lifted off from the central southern hemisphere between around 04/0300-0400UTC. Further imagery is awaited to model the associated CME, however initial images appear to indicate a faint and not particularly fast CME, with ejecta largely directed south of the Sun-Earth line.

Solar Wind / Geomagnetic Activity: Solar wind speeds, observed at L1, fluctuated between 400-450km/s. Density rose to above average levels, peak 22ppcc, between 03/1930-04/0200UTC, otherwise was average or below average. Total magnetic field strength was initially weak but gradually increased through the period, more noticeably after 04/0130UTC, becoming strong and with ongoing peak around 19nT. The north-south component, Bz, also became moderate and southward pointed for several hours after 04/0130UTC, peak -12nT, before gradually rotating to a current weak northward orientation. Phi angle was predominantly positive (towards the Sun), but varied periodically before 03/2100 UTC with occasional incursions into the negative (away from Sun) sector. Geomagnetic activity was initially Quiet before increasing to Unsettled to G1/Minor Storm (Kp 3-5) from 03/2100UTC, as observed by BGS.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) began the period at high levels, with a peak of 4100 pfu at 03/1605 UTC before dropping to largely background levels after midnight UTC. The 24-hour integrated electron fluence has been above the Active threshold but now on a falling trend and will likely drop below Active soon.
The observed fluence at 03/2359 UTC was 1.43e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Low solar activity is expected on 04 January, with an increased chance of M-class and X-class flares from 05 January due to the apparent active regions beyond the eastern limb, soon to become visible from Earth.

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Solar Wind / Geomagnetic Activity: No Earth-directed CMEs are currently expected during the four-day forecast period. Solar wind speeds are presently at Slightly Elevated levels owing to the likely passage of 30th December CME. The high speed streams from negative coronal holes 60 and 61 are due to affect the Earth either on 04 or 05 January (Day 1 or 2), with estimated speeds in the region of 450-500km/s. These Slightly elevated to Elevated solar wind speeds are expected to persist to the end of the forecast period with a slow downward trend from the 05 or 06 January. Geomagnetic activity will generally be Unsettled through the next 24 hours, but with a risk of Active or G1/Minor Storm intervals due to residual CME effects and then the anticipated onset of one or more coronal hole HSS later on 04 or early 05 January. Further G1/Minor Storm intervals are then possible through 05 January due to the effects of any coronal hole connection, with a return to Quiet to Unsettled conditions expected by 06 or 07 January (Day 3 or 4).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout but with a chance of rising alongside any notable flares, giving a slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) at GOES-16 have fallen to background levels, but may increase again from 05 January (Day 2) back to High levels. Further more persistently reduced flux levels are likely from 05 January due to the possible effects of the coronal hole high speed stream connections, but there is low confidence in the impact of these effects. Later on 06 or 07 January (Day 3 or 4), flux could increase back to persistently High levels again as geomagnetic activity subsides. Electron fluence levels are expected to soon reduce below the Active threshold 04 January, with greater uncertainty from 05 January due to the potential geomagnetic enhancements.

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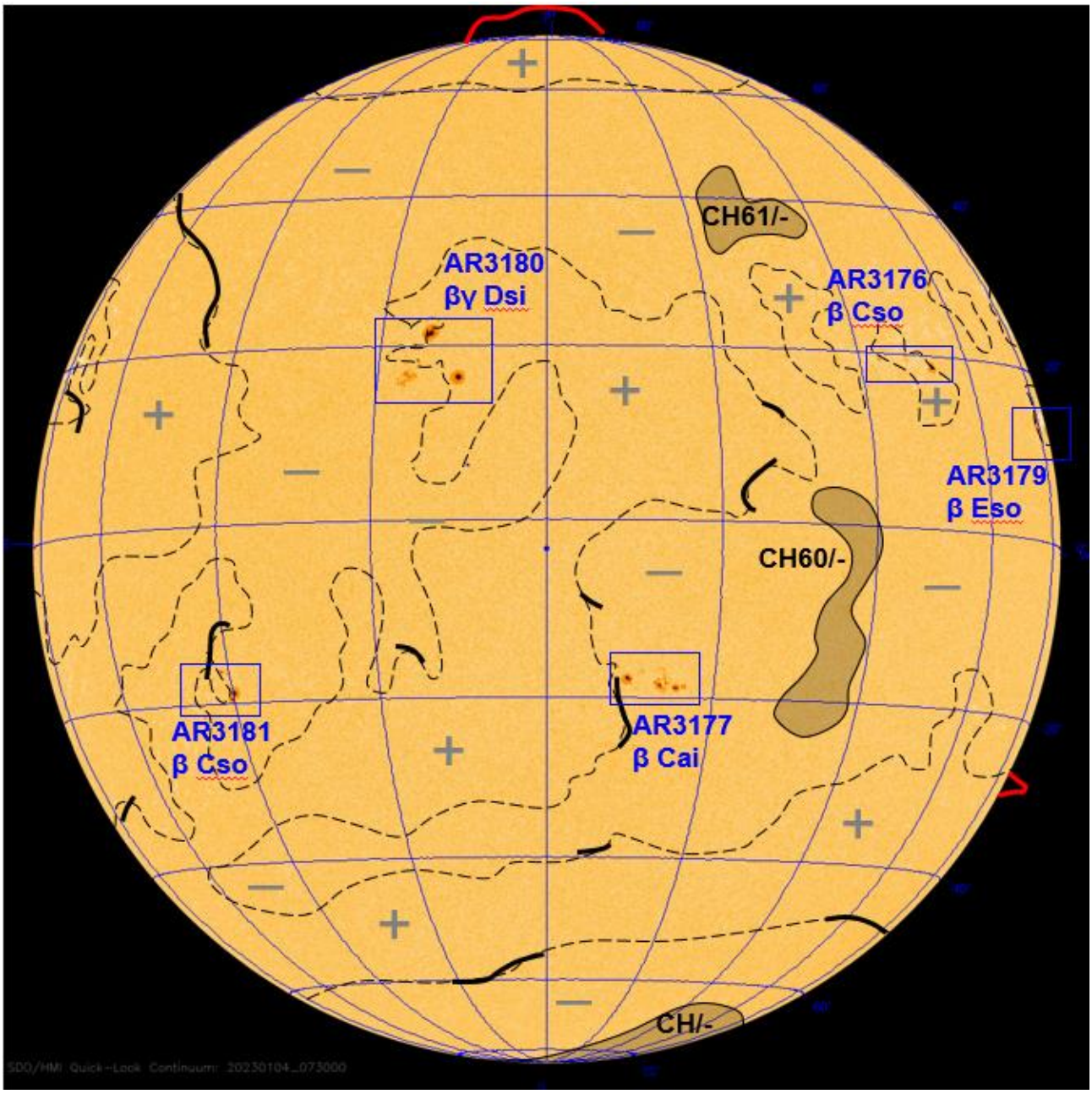
Figure 1. Solar Analysis Valid 04/0800 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December is likely to be passing Earth at present, given observed solar wind parameters. No other Earth-directed CMEs are currently expected during the four-day forecast period. However, a filament lifted off from the central southern hemisphere between around 04/0300-0400UTC. Further imagery is awaited to model the associated CME, however initial images appear to indicate a faint and not particularly fast CME, with ejecta largely directed south of the Sun-Earth line.

Solar wind speeds have fluctuated at Slightly Elevated levels with no large increase in speeds associated with the likely CME passage. The high speed streams from negative coronal holes 60 and 61 are due to affect the Earth either on 04 or 05 January (Day 1 or 2), with coronal hole 60 likely to produce a stronger connection due to the relative position of Earth to the coronal hole. Analysis of albeit patchy STEREO-A data suggests that the hole has still not yet connected with this spacecraft, suggesting that any connection at Earth will more likely be early on 05 January. In the absence of observations for the high speed stream from STEREO-A, speeds of 450-500km/s are estimated given an apparent decline in the size of the coronal hole since the past rotation in early December. Slightly elevated to Elevated solar wind speeds are then expected to persist to the end of the forecast period with a slow downward trend from the 05 or 06 January.

Geomagnetic activity will generally be Unsettled through the next 24 hours, but with a risk of Active or G1/Minor Storm intervals due to residual CME effects and then the anticipated onset of one or more HSS later on 04 or early 05 January. Further G1/Minor Storm intervals are then possible through 05 January due to the effects of any HSS connection, with a return to Quiet to Unsettled conditions expected by 06 or 07 January (Day 3 or 4).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	40	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

None expected

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Figure 2: Solar wind parameter as measured by DSCOVR and ACE satellites.

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Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the last 24 hours, with occasional C-class flares. However, much of the flare activity can be attributed to an active region beyond the eastern limb in the southern hemisphere. This area was responsible for a long period C4.0 flare on 03 January, though was likely much stronger, given its occulted position relative to Earth. As this region and others rotate onto the visible disc in the next day or two, the risk of both M-class and X-class flares are increased between Day 1 levels on 04 January and Day 2 on 05 January.
There are currently five sunspot regions on the visible disc. Most regions are either steady state, or in slow decline apart from AR3181 (Cso/Beta) in the southeast, which has developed some small peripheral spots. AR3180 (Dsi/Beta) in the northeast remains the largest region, but the trailer portion has shown some slight decay in recent imagery.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	40	50	50
Very Active	R3 to R5 X Class	No	5	10	10	10

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, due mainly to the risk presented by the far-sided active regions which are just beyond the eastern limb.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	10	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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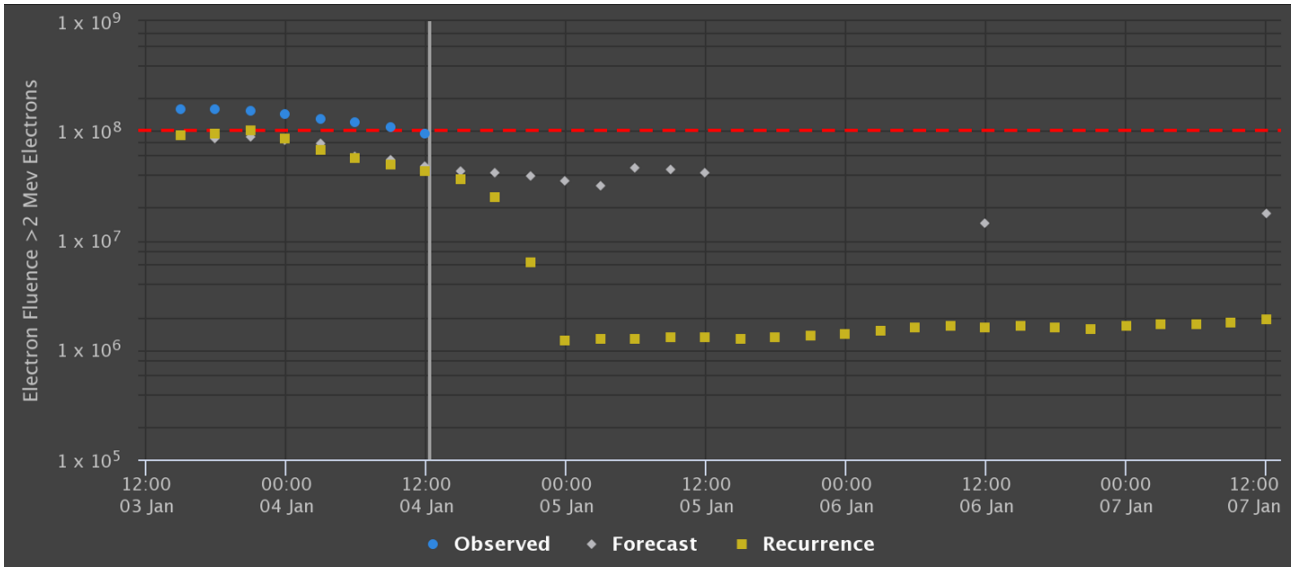
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) began the period at high levels but has dropped to Background due to enhanced Geomagnetic activity associated with a likely CME passage. Broadly lower electron counts at GEO are anticipated to continue for a time ahead of the onset of further Geomagnetic activity associated with one or more CH HSS forecast to arrive either late 04 or early 05 January (Day 1 or 2). The timing of the onset of these features will determine when electron counts can rise again up to High levels, now more likely on Days 3 and 4 (6 and 7 January) when the electron belts are likely to rebound.

Electron fluence is now expected to drop below the Active threshold on 04 January, given current trends in electron flux. There is lower confidence in the fluence forecast into 05 January, as the overall level will be dependent on the balance between the strength of the solar wind and the magnitude of any geomagnetic activity. Based on the lower than average confidence in the forecast potential effects of the coronal hole connections, the forecast gives a chance of rising again to/above the Active fluence threshold from Day 2 onwards.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	40	50	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 3: MOSWOC REFM (above) and GOES16 High energy electron flux (below)



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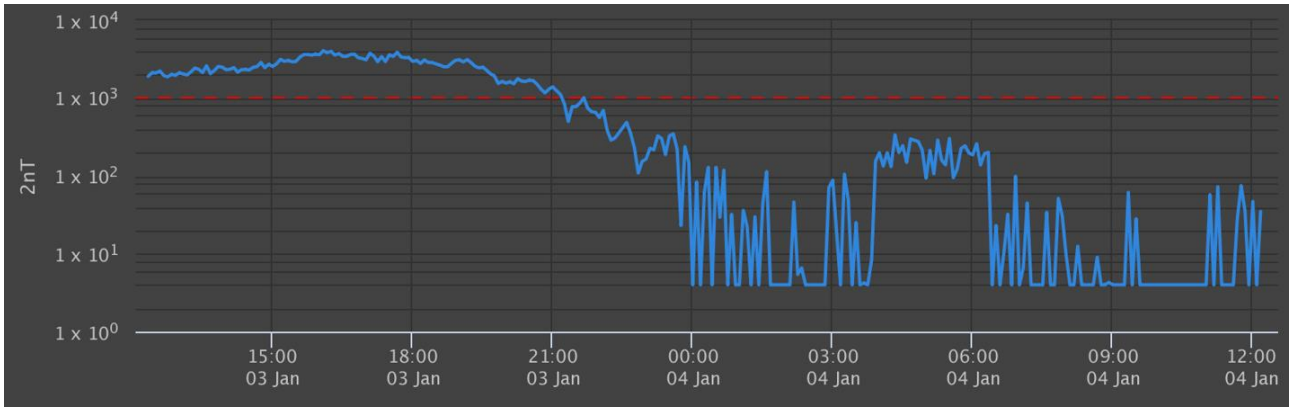

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